

Genetic and Environmental Sources of Individual Religiousness: The Roles of Individual Personality Traits and Perceived Environmental Religiousness

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Abstract In the current study, we examined the genetic and environmental sources of the links between individual religiousness and individual personality traits, perceived parental religiousness, and perceived peer religiousness. Data from 870 individuals (incl. 394 twin pairs) were analyzed. Variance in individual religiousness was significantly influenced by genetic effects, environmental influences shared by twins reared together, and individual-specific environmental influences. Individual religiousness showed significant associations with age, sex, specific personality traits (e.g., agreeableness, openness to values), and perceived religiousness of important social interaction partners, such as parents, best friends, and spouses. The links to personality traits were relatively small and primarily genetically mediated. The associations between individual religiousness and parental religiousness were substantial and mediated by shared environmental effects. These links significantly decreased across age accompanying a significant decrease of shared environmental influences on individual religiousness. The correlations between individual religiousness and perceived religiousness of spouses and best friends were relatively moderate but increased with age. These associations were mediated by genetic as well as nonshared environmental sources accompanying an increase of nonshared environmental influences on individual religiousness with age. The results suggest that inter-individual differences in religiousness are due to multiple sources.

Keywords Personality · Twin study · Perceived parental · Peer religiousness · Individual religiousness

Introduction

Why do people differ in their levels of religiousness, religious beliefs and practices irrespective of a specific chosen religion and associated established traditions? Behavioral genetic studies have consistently shown that individual differences in religiousness and related values are influenced by contextual and situational factors that are shared and not shared by family members, but are also due to genetic effects (Button et al. 2011; Renner et al. 2012; Koenig et al. 2008). The current study was conducted to understand the underlying etiology of genetic and environmental sources of variance in religiousness. For that purpose, we analyzed individual personality traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness) and perceived religiousness of important social interaction partners (parents and peers) as potential predictors of variance in individual religiousness and as potential mediators of genetic and environmental sources.

Genetic sources of variance in religiousness

Estimates of heritability of individual religiousness depend on the age studied. Studies on adolescent religiousness have reported small or non-significant heritability estimates, ranging between 2 and 29 % (Abrahamson et al. 2002; Button et al. 2011; Koenig et al. 2008; Winter et al. 1999). Studies of adult religiousness have generally found larger genetic contributions accounting for 27 to 65 % of the variance (Bradshaw and Ellison 2008; D'Onofrio et al.

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1999; Eaves et al. 1999; Koenig et al. 2005; Maes et al. 1999). The increase of heritability during the transition from adolescence to adulthood has often been interpreted as increasing contributions of active genotype-environment correlation. That is, adults make their own decisions that allow genotypes to more fully express themselves, to select environments that match their genetic predispositions, and to actively change environments (Koenig et al. 2008; Scarr and McCartney 1983).

Since it is counterintuitive that specific genes may directly influence religious beliefs and behavior, it is important to understand the nature of these genetic influences. Individual personality traits are promising candidates that may explain (i.e., mediate) genetic contributions to individual differences in religiousness because of different reasons. First, variance in personality traits is strongly genetically influenced and relatively stable across time (Kandler et al. 2010a, b). Second, different operationalizations and dimensions of religiousness are positively associated with agreeableness and conscientiousness as well as related personality facets (Saroglou 2010; Saroglou and Fiasse 2003). Third, longitudinal studies have consistently shown that personality traits predict religiousness rather than vice versa (McCullough et al. 2003; Wink et al. 2007). Based on these findings, some authors conceptualize individual religiousness as individual characteristic adaptation of more basic personality traits in different social and cultural contexts (McCrae and Costa 2008; Saroglou 2010). However, no study, until now, has investigated whether genetic contributions to basic personality traits, such as agreeableness and conscientiousness, account for the genetic variance in religiousness, although this would directly support the conceptualization of religiousness as characteristic adaptation.

When studying the associations between personality and religiousness, age and sex differences have to be controlled. Religiousness tends to decrease during the transition from adolescence to adulthood (Button et al. 2011; Uecker et al. 2007) but then, on average, increases slightly throughout adulthood (Argue et al. 1999; McCullough et al. 2005). This age trend of religiousness nearly parallels the trends of the most robust correlates agreeableness and conscientiousness, which decline in adolescence but then increase across adulthood (Soto et al. 2011). Also, females are, on average, more religious than males (Button et al. 2011; Miller and Stark 2002; Wink et al. 2007) and tend to be more agreeable and conscientious (Soto et al. 2011).

A recent meta-analysis showed significant relations between religiousness and self-enhancement (Sedikides and Gebauer 2010). Consequently, the links between particular personality traits and individual religiousness may be artificial due to impression management distorting self-reports, if both personality and religiousness are captured by self-

reports. Although studies using different informants including parents and teachers or various observers have also found significant links between personality and religiousness that helps to exclude bias explanations (McCullough et al. 2003; Saroglou and Fiasse 2003; Wink et al. 2007), different raters are helpful to control for confounding self-rater biases.

Environmental sources of variance in religiousness

Beyond genetic contributions, environmental influences shared by individuals raised in the same family that act to make them similar to each other contribute to the variance in religiousness. Shared environmental influences may reflect intra-familial effects, such as the influence of parents (i.e., an influence beyond genetic transmission from parents to offspring, see below) and other relatives, or extra-familial influences by common friends or neighborhood, but also shared economic and cultural effects, such as socioeconomic status or religious community. The size of shared environmental effects depends on the operationalization of religiousness and the developmental period investigated. Estimates range between 25 and 74 % for adolescents and young adults (Koenig et al. 2008; Eaves et al. 2008) and between 4 and 33 % for adults (Bradshaw and Ellison 2008). The decrease in variance accounted for by shared environmental influences might be attributable to the fact that the influences of parents decline after offspring leave their parental home. Consequently, the influence of perceived parental religiousness on offspring's religiousness should decrease with age.

Supposed shared environmental influences are not necessarily shared by family members. The same parents may differently influence their offspring and siblings may differently experience or interpret the same parental influence. These environmental influences are effectively not shared by individuals raised in the same family, but are unique to individuals and act to make siblings different to each other. Nonshared environmental influences on family members, such as twin pairs, may also reflect effects from different friends, residences (after leaving their parental home), communities, and individual life events (e.g., marriage, birth of own child, accidents, death of close friends or relatives), and contain random measurement error. Several studies have found that 28 to 55 % of the variance in religiousness is attributable to nonshared environmental effects (Bradshaw and Ellison 2008). Genetically informative longitudinal studies indicate that nonshared environmental effects are the primary source of change in religiousness (Button et al. 2011; Koenig et al. 2008). After leaving parental home, the influence of social environments not shared by twins (e.g., different friends, residential environments, communities, and spouses) may gain more

importance. Longitudinal studies on personality traits have shown that individual-specific environmental effects on the variance may accumulate across adulthood (Kandler et al. 2010a; Viken et al. 1994). If nonshared environmental effects also accumulate in religiousness, the contribution of these effects to the variance in religiousness should be larger for older than for younger adults.

The interplay between genetic and environmental sources

It should be noted that the variance in perceived parental, peer, and spousal religiousness may be influenced to some degree by genetic effects due to several reasons. First, the perception or interpretation of social environments may be influenced by genetic factors. Second, perceived parental religiousness is certainly linked to actual parental religiousness which, in turn, may be genetically linked to offspring's religiousness due to genetic transmission from parents to offspring or due to passive genotype-environment correlation (i.e., parents select environments that match their genetically predisposed religiousness and these environments, in turn, affect offspring's religiousness). Third, variance in perceived peer and spousal religiousness may show genetic influences due to active and reactive genotype-environment correlation (e.g., individuals assort friends and partners or evoke social reactions that match their genetic predisposed religiousness). Consequently, estimates of genetic effects on the variance in self-reports on social environments are plausible, due to genetically influenced perceptions of environments, genetically affected exposure to environments, or genetic relatedness to (or assortment of) certain social interaction partners. These genetic effects can be mediated by personality traits linked to genetic variance in individual religiousness.

Aims of the current study

The current study was designed to understand the nature of genetic and environmental sources of the variance in religiousness. Because of the expected differences between younger and older individuals according to previous research (i.e., age should be negatively related to religiousness from late adolescence to young adulthood, whereas religiousness and age should be positively linked in middle and late adulthood), we analyzed the data with regard to two age groups. One group included late adolescents and young adults, aged 17–30. The other group subsumed middle and late adults, aged 31–82.

First, we investigated the associations between individual religiousness and (1) age and sex, (2) personality

domain traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness) as well as personality facet residuals (i.e., facet scores corrected for variance in domain traits), and (3) perceived religiousness of important social interaction partners (mother's, father's, best friend's, and spouse's religiousness) to detect potential predictors of individual religiousness. In line with previous studies (Saroglou 2010), agreeableness as well as conscientiousness should show significant positive links to religiousness. We used self-reports and peer assessments of personality traits to validate the correlations between personality traits and individual religiousness across different informant perspectives (i.e., among peer reports on personality and self-reports on religiousness) excluding potential self-rater biases as alternative explanations for the associations. In line with the thought that adults make their own decisions that allow genetic predispositions to more fully express themselves (Scarr and McCartney 1983), we expected higher correlations between individual religiousness and personality traits for middle and late adults. In addition, since parental religiousness should be more important in younger ages (Koenig et al. 2005) the links between individual religiousness and perceived parental religiousness should be larger in late adolescents and young adults. In contrast, the associations between individual religiousness and perceived religiousness of best friends and spouses should be larger in middle and old adults.

Second, we estimated genetic and environmental contributions to the variance in individual religiousness. According to the consideration that adults select and evoke environments that match their genetic predispositions and act to increase heritability across age, we expected larger genetic contributions for middle and late adults. We also estimated genetic and environmental effects on the variance in perceived parental and peer religiousness. Variance in perceived parental religiousness should be primarily due to shared environmental effects. Variance in peer religiousness was expected to be primarily attributable to individual-specific environmental contributions.

Third, we analyzed to what degree genetic and environmental variance in individual religiousness was shared with genetic and environmental components of personality traits and perceived religiousness of parents and peers. If personality traits mediate genetic contributions to the variance in religiousness, the links between personality traits and individual religiousness should be due to genetic effects. If perceived parental religiousness reflects environmental effects on individual religiousness shared by twins, the associations between perceived parental religiousness and individual religiousness should be mediated by shared environmental effects. And, if perceived peer religiousness reflects individual-specific environmental effects on individual religiousness, the links between peer

religiousness and individual religiousness should reflect nonshared environmental correlations.

Methods

Participants

The sample consisted of 870 individuals including 226 monozygotic (MZ) and 168 (DZ) dizygotic twin pairs (82 unmatched twins) reared together from the jena twin study of social attitudes (JeTSSA). Twins ranged in age from 17 to 82 years (on average 34 years) and 74 % of the participants were women. The sample was heterogeneous with regard to education and occupational status. More information on the sample was provided by Stöbel et al. (2006).

Since we wanted to analyze the data with regard to two age groups (adolescents to young adults and middle to old adults), we split the sample into two subsamples with relatively equal sample size. The younger group included people aged between 17 and 30 ($N = 412$; incl. 116 MZ and 78 DZ pairs, 24 unmatched twins). The older group included individuals aged between 31 and 82 ($N = 458$; incl. 110 MZ and 90 DZ pairs, 58 unmatched twins).

Measures

Personality

Twins' personality traits were captured by the German version of the neuroticism-extraversion-openness personality inventory revised (NEO-PI-R; Costa and McCrae 1992; Ostendorf and Angleitner 2004). The NEO-PI-R consists of 240 items designed for measuring personality on 30 facet scales and the Big Five domain scales (neuroticism, extraversion, openness, agreeableness, and conscientiousness). Each facet scale encompasses eight items and each domain scale comprises six facet scales (48 items). Twins provided self-reports and different well-informed acquaintances for each twin of a pair provided peer reports. In the current study, internal consistency (Cronbach's α) of facet scales ranged from $\alpha = .52$ (openness to values) to $\alpha = .84$ (anxiety) for self-reports and from $\alpha = .53$ (openness to values) to $\alpha = .83$ (self-discipline) for peer reports. Internal consistency of domain scales ranged from $\alpha = .85$ (agreeableness) to $\alpha = .91$ (neuroticism) for self-reports and from $\alpha = .87$ (openness) to $\alpha = .92$ (conscientiousness) for peer reports. Self-peer correlations ranged from $r = .28$ (straightforwardness) to $r = .58$ (assertiveness) for facet scores and from $r = .44$ (agreeableness) to $r = .62$ (extraversion) for domain scores. Further psychometric properties of the domain scales in the present sample as well as genetically

informative univariate twin analyses of self- and peer reports were presented previously (Kandler et al. 2009). Since specific domain and facet-level traits are highly correlated because of the hierarchical structure of personality, we regressed out the variance due to the domain traits from each of the 30 facet scores and used facet residual scores in addition to the domain trait scores in the ongoing analyses.

Individual religiousness

Because of the heterogeneity of operationalizations of religiousness across different studies, we used a more direct strategy to capture individual religiousness. Twins rated their religiousness on an item "I am..." followed by a five-point scale from "not religious" to "religious". In addition, each individual assessed the religiousness of their cotwin on an item "My twin brother/sister is..." followed by a five-point scale from "not religious" to "religious". We combined the individual's self-rating and the cotwin's rating. The internal consistency of this two-item composite was $\alpha = .83$ for the entire sample with complete twin and cotwin data ($N = 777$), $\alpha = .86$ for younger ($N = 385$), $\alpha = .80$ for older participants ($N = 392$), $\alpha = .85$ for MZ twins ($N = 446$), and $\alpha = .79$ for DZ twins ($N = 331$).

Perceived parental and peer religiousness

In addition to their own religiousness and the cotwin religiousness, twins assessed the religiousness of their mothers, fathers, best friends, and spouses given that they know their parents and that they have friends and spouses. Most twins rated the religiousness of their mothers ($N = 835$; 96 %) and fathers ($N = 788$; 91 %). Reports on best friends' religiousness were provided by 740 (85 %) individuals and only 597 (69 %) individuals rated their spouses' religiousness. The latter was particularly due to fact that only 216 (52 %) of the younger people (age ≤ 30) were married or at least cohabited.¹ Perceived mothers' and fathers' religiousness showed high correlations across both age groups ($r = .66$, $N = 391$ for the younger sample; $r = .65$, $N = 381$ for the older group). The correlations between perceived best friends' religiousness and spouses' religiousness were moderate ($r = .32$, $N = 191$ for the younger sample; $r = .28$, $N = 332$ for the older group). There were also moderate correlations among parental and

¹ We checked for possible differences between people with and without partners. People with partners showed lower levels of neuroticism ($d = .21$; $p < .01$) and excitement seeking ($d = .38$; $p < .001$) and a higher degree of extraversion ($d = -.19$; $p < .01$) and conscientiousness ($d = -.31$; $p < .001$). However, participants with and without spouse data did not differ significantly in individual religiousness and other personality variables.

peer religiousness ranging between $r = .18$ and $r = .43$ for younger people and between $r = .28$ and $r = .33$ for older people.

Analyses

Missing data handling

We used different strategies for handling missing data. First, for phenotypic correlation and regression analyses we used pairwise deletion procedures. Second, MZ and DZ variance–covariance matrices for genetically informative analyses were estimated by using expectation maximization (EM) procedures (Little and Rubin 2002). In addition, we handled missing values by calculating composites for personality traits (averaging self- and peer reports) and individual religiousness (averaging twin and cotwin reports) when at least one assessment was available. That is, if one of those scores was missing, the composite was the non-missing score.

Phenotypic correlation analyses

We investigated the associations between individual religiousness and age, sex, personality traits, as well as perceived social environments (mother's, father's, best friends', and spouse's religiousness) by using product moment correlations. Correlations with personality traits were estimated for each rater perspective (i.e., self- and peer reports) to explore potential dependencies regarding different rater perspectives (Sedikides and Gebauer 2010). We compared the correlation coefficients between the younger group (age ≤ 30) and the older group (age > 30) by using the z-test.

Multiple hierarchical regression analyses

In addition to bivariate correlations, we calculated multiple hierarchical regressions of individual religiousness on potential predictors to identify significantly linked personality domain traits and facet residuals as well as parental and peer religiousness controlled for age and sex differences as well as controlled for correlations among potential predictors. First, we ran a model with age and sex as predictors (step 1) and then included personality domain traits and facet residuals that have shown significant bivariate associations with individual religiousness (step 2). Third, we included parental, best friend, and spouse religiousness (step 3). For each step, we estimated the increase of variance that could be accounted for by the inclusion of new potential predictors. Finally, we used a stepwise procedure to find the best regression model. These

analyses were done for both the younger sample (age ≤ 30) and the older sample (age > 30), separately.²

Univariate variance component analyses

For both age groups, we estimated twin correlations within individual religiousness and each potential predictor variable, which has shown a significant link to individual religiousness. As sex and age effects can bias the estimates of twin similarity, twin correlations were based on data corrected for age and sex effects (McGue and Bouchard 1984). Furthermore, we ran univariate four-group twin models based on MZ and DZ variance–covariance matrices of the younger as well as the older MZ and DZ twin pairs. These models provided estimates of (additive) genetic and environmental effects (shared and not shared by twins) on the variance in individual religiousness and potential predictors. Assuming the absence of gene–environment correlations, gene $\times$ environment interactions, and nonadditive genetic effects due to allelic dominance deviations, the genetic and environmental parameters were estimated by fitting the structural equation model via maximum likelihood procedures using the statistical software package Mx (Neale et al. 2003). The overall model fit was evaluated by the root mean square error of approximation (RMSEA $< .05$ indicates a good fit and RMSEA $< .08$ indicates an acceptable fit). We tested the expected differences between age groups regarding the genetic and environmental contributions to the variance in religiousness with the χ^2 -difference test. We also tested age differences for all potential predictor variables. For that purpose, we equated genetic and environmental parameters across both age groups and compared the model fit of the restricted model against the model fit of the non-constrained (full) model. In addition, we evaluated the significance of specific genetic and environmental parameters by confidence intervals and tested for more parsimonious models in which non-significant parameters were fixed to zero.

Multivariate variance component analyses

We ran genetically informative Cholesky decomposition models (Neale et al. 2003) to estimate genetic and

² McCullough et al. (2003) found a significant interaction between neuroticism and the strength of religious upbringing predicting religiousness in early adulthood. Thus, personality traits may also interact with the effects of individuals' social environments (e.g., parental and peer religiousness) on individual religiousness in adulthood. Therefore, we also tested for personality $\times$ parental religiousness interactions as well as personality $\times$ peer religiousness interactions accounting for variance in individual religiousness. However, neither for the younger nor for the older group we found significant personality $\times$ parental religiousness interactions or personality $\times$ peer religiousness interactions.

environmental variance components in individual religiousness that could be accounted for by genetic and environmental effects on the variance in potential predictor variables ($g_{PT}^2 + g_{PA}^2 + g_{PS}^2$ and $e_{PT}^2 + e_{PA}^2 + e_{PS}^2$; see Fig. 1) and that were specific to individual religiousness (g_s^2 and e_s^2). These models underlie the same assumptions as the univariate models. For parsimony, we only included the significant predictors based on the results of the phenotypic multiple hierarchical regression analyses (in the same order) for each age group, separately. Thus, each predictor variable in the Cholesky model allowed for incremental prediction of variance in individual religiousness. Again, the overall model fit was evaluated by the RMSEA. We also ran reduced models according to univariate model fitting results. This should not significantly reduce the model fit but should lead to more statistical power of specific parameter estimations. We further tested whether phenotypic links were mediated by genetic or environmental effects. That is, we tested (1) whether personality traits primarily mediate the genetic influences, (2) whether perceived parental religiousness primarily account for the shared environmental influences, and (3) whether perceived peer religiousness is primarily linked to the nonshared environmental effects on the variance in individual religiousness. This was done by fixing the parameters of interest to zero and by comparing the resulting more parsimonious models with more complex models by using the χ^2 -difference test. In addition, we estimated genetic and environmental correlations via converting the pathways between two variables in the Cholesky model into latent correlations. Latent genetic and environmental correlations indicate the extent to which the genetic or environmental factors on a potential predictor variable and the genetic or environmental factors on individual religiousness were linked (disregarding the effects of other predictor variables equal to an independent calculation of latent bivariate genetic and environmental correlations; see Fig. 2). The significance of these links was evaluated by confidence intervals.

Results

Phenotypic correlation analyses

Correlations between individual religiousness (composite score of self- and cotwin reports) and age, sex, personality traits, and perceived religiousness of social environments (mother's, father's, best friend's, and spouse's religiousness) for both age groups are shown in Table 1. As expected and in line with previous studies (e.g., Argue et al. 1999), age was significantly correlated with individual religiousness only in the older group reflecting a

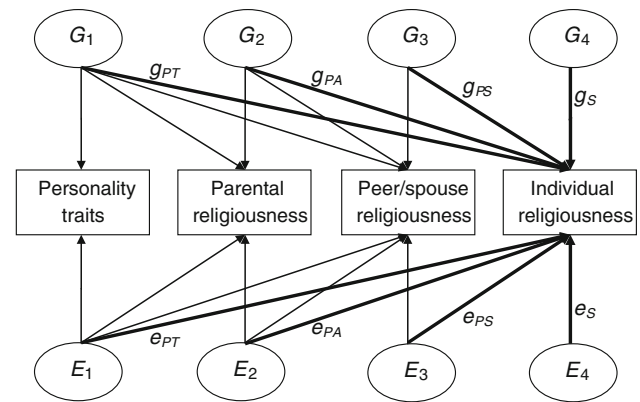


Fig. 1 This figure illustrates the Cholesky decomposition model which decomposes genetic (G) from environmental effects (E , for simplicity not decomposed into environmental effects shared and nonshared by twins) on individual religiousness (**bold paths**) specific to individual religiousness (g_s, e_s) and common with personality traits (g_{PT}, e_{PT}), perceived parental (g_{PA}, e_{PA}) and peer religiousness (g_{PS}, e_{PS}). For simplicity, the model is shown for only one twin. Only one variable is shown for multiple personality traits and one variable for peer religiousness that can reflect both perceived best friend and spouse religiousness. See text for more clarification

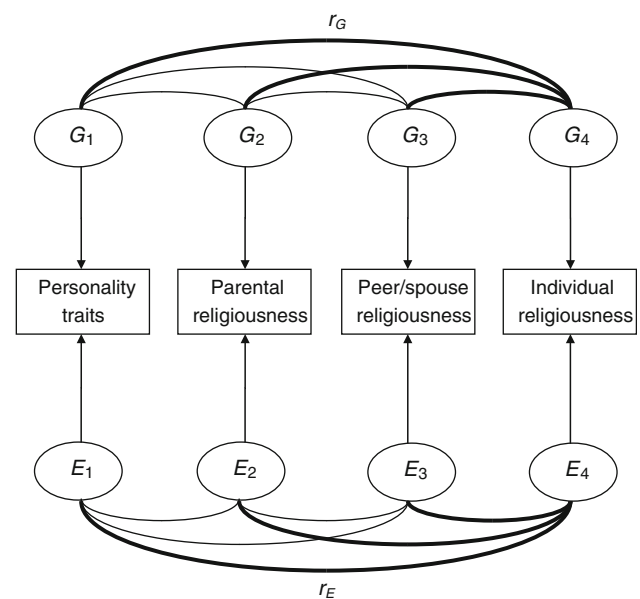


Fig. 2 This figure illustrates a model (equal to the model in Fig. 1 regarding the degrees of freedom but without directionality of effects) which allows an estimation of independent latent genetic (r_G) and environmental correlations (r_E) between potential predictor variables and individual religiousness (**bold paths**). For simplicity, the model is shown for only one twin. Only one variable is shown for multiple personality traits and one variable for peer religiousness that can reflect both perceived best friend and spouse religiousness. See text for more clarification

nonlinear increase of religiousness with age. Also in line with previous research (e.g., Miller and Stark 2002), women showed higher levels of religiousness.

Table 1 Phenotypic correlations between individual religiousness and potential predictors

Potential predictors	Individual religiousness				Fisher's z test
	Age ≤ 30		Age > 30		
	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>	
Demographic variables					
Age	412	.07	458	.21**	−2.07*
Sex	412	.13*	458	.12*	.07
Big Five personality traits					
Neuroticism					
Self-reports	411	−.01	456	.04	−.70
Peer reports	362	.04	386	.08	−.59
Composite	412	.01	458	.07	−.94
Extraversion					
Self-reports	411	.07	455	−.04	.46
Peer reports	362	−.04	386	−.05	.12
Composite	412	.03	457	−.03	.92
Openness					
Self-reports	411	.16**	454	.14**	.25
Peer reports	362	.11**	386	.06	.78
Composite	412	.17**	456	.15**	.33
Agreeableness					
Self-reports	411	.18**	455	.19**	−.18
Peer reports	362	.18**	386	.18**	−.06
Composite	412	.19**	457	.21**	−.41
Conscientiousness					
Self-reports	411	.14**	456	.01	1.94 ⁺
Peer reports	362	.14**	386	.01	1.83 ⁺
Composite	412	.15**	458	.00	2.19*
Significantly linked personality facet residuals					
Warmth ^a					
Self-reports	411	.04	454	.15**	−1.63
Peer reports	362	.13*	386	.12*	.14
Composite	412	.09 ⁺	456	.15**	−.89
Excitement seeking ^a					
Self-reports	411	−.10*	454	−.14**	.59
Peer reports	362	−.12*	386	−.13**	.14
Composite	412	−.12*	456	−.14**	.30
Openness to values ^a					
Self-reports	411	−.16**	454	−.20**	.61
Peer reports	362	−.19**	386	−.28**	1.30
Composite	412	−.20**	456	−.27**	1.09
Modesty ^a					
Self-reports	411	−.14**	454	−.21**	1.06
Peer reports	362	−.09 ⁺	386	−.24**	2.10*
Composite	412	−.14**	456	−.27**	1.99*
Parental and peer religiousness					
Parental religiousness					
Mother	410	.75**	425	.54**	5.39**
Father	392	.63**	385	.55**	1.86 ⁺
Composite	411	.76**	429	.59**	4.58**

Table 1 continued

Potential predictors	Individual religiousness				Fisher's z test
	Age ≤ 30		Age > 30		
	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>	
Peer religiousness					
Best friend	343	.26**	396	.38**	−1.79 ⁺
Spouse	216	.33**	380	.45**	−1.68 ⁺

N number of individuals with complete data, *r* correlation coefficients

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits

Across both self- and peer reports of personality domain traits, we found the expected significant positive associations between agreeableness and individual religiousness as well as between conscientiousness and individual religiousness (contradicting bias explanations). Openness also showed positive links to religiousness across age groups, whereas neuroticism and extraversion showed negligible associations with religiousness. We also found significant associations with four personality facet residuals which were corrected for the contribution of Big Five traits. Though extraversion was not significantly linked to religiousness, we found significant links to the extraversion-related facets warmth and excitement seeking. Higher warmth and lower excitement seeking was associated with higher individual religiousness scores. Though the domain traits openness and agreeableness showed positive links to religiousness, we additionally found negative associations with the openness-related facet openness to values and with the agreeableness-related facet modesty.

Not in line with our hypotheses, the correlations between personality domain traits and religiousness were not significantly larger for older individuals. To the contrary, the links between conscientiousness and religiousness were not significant for people older than 30. However, for agreeableness and each of the significantly linked facet trait residuals, the correlations with individual religiousness at least tended to be larger for older people.

Perceived parental and peer religiousness were positively linked to individual religiousness. In line with our hypotheses, the associations with parental religiousness were larger for younger people, whereas the correlations with best friend's and spouse's religiousness were larger for older adults.

Multiple hierarchical regression analyses

Since the use of self- and peer reports of personality did not yield different results with regard to the correlations between personality variables and individual religiousness,

we used composite scores (averaging self- and peer reports) of personality domain traits and facet residuals for the multiple regression and ongoing analyses. Because of the high correlation between perceived mothers' and fathers' religiousness ($r > .65$) we aggregated both items and used the composite parental religiousness as predictor variable to avoid multi-collinearity. Given moderate correlations between perceived spouse's religiousness and best friend's religiousness ($r < .35$), we decided to investigate them as separate variables of peer religiousness for the multiple regression and further analyses.

For both age groups, the inclusion of personality traits in a regression model (step 2) yielded a significant increase of accounted variance (see Table 2). The sex effects reduced to zero. Thus, sex differences that are linked to religiousness were completely mediated by personality traits. The inclusion of perceived parental, spouse, and best friend religiousness in the regression model (step 3) yielded a significant increase of explained variance compared to the former model (step 2) for the older as well as for the younger subsample. However, perceived best friend's and spouse's religiousness showed no significant influences in the

presence of effects from perceived parental religiousness and personality traits in young adulthood. To the contrary, both perceived best friend's and spouse's religiousness accounted for a significant variance proportion in addition to the perceived parental religiousness in older adulthood.

For younger people, the effects from agreeableness, conscientiousness, openness to values, and modesty decreased after parental religiousness was included. This suggests that parental religiousness mediated the effects of particular personality traits on individual religiousness reflecting passive personality-environment correlation. For instance, more agreeable and conscientious parents may have more agreeable and conscientious offspring as well as provide more religious environments resulting in higher levels of individual religiousness in their offspring. In fact, agreeableness, conscientiousness, openness to values, and modesty showed significant correlations with perceived parental religiousness (see Table 3). The Sobel test (Sobel 1982) yielded a significant partial mediation for agreeableness ($z = 2.75$; $p < .01$), conscientiousness ($z = 2.37$; $p < .05$), openness to values ($z = -2.75$; $p < .01$), as well as modesty ($z = -2.74$; $p < .01$).

Table 2 Multiple regressions from individual religiousness on age, sex, personality traits, and perceived religiousness of parents and peers for two age groups

Regression models	Age ≤ 30 ($N = 412$)				Age > 30 ($N = 458$)			
	Step 1	Step 2	Step 3	Best	Step 1	Step 2	Step 3	Best
Explained variance								
R^2	.02*	.15**	.65**	.64**	.08**	.26**	.55**	.54**
ΔR^2		.13**	.50**	-.01		.18**	.30**	-.01
Effects (standardized β weights)								
Step 1								
Age	.08	.08	.07		.23**	.12*	.02	
Sex	.13*	.04	.00		.13*	.06	.06	
Step 2								
Openness		.11*	.10**	.10**		.11*	.09*	.10*
Agreeableness		.14**	.06 ⁺	.07*		.15**	.09*	.11*
Conscientiousness		.13**	.06 ⁺	.06*		-.01	.01	
Warmth ^a		.03	.03			.10 ⁺	.10*	.12**
Excitement seeking ^a		-.09 ⁺	-.04			-.07 ⁺	-.05	
Openness to values ^a		-.21**	-.11**	-.09*		-.26**	-.16**	-.17**
Modesty ^a		-.13*	-.03			-.27**	-.17**	-.17**
Step 3								
Parental religiousness			.73**	.75**			.40**	.40**
Best friend religiousness			.03				.11*	.12**
Spouse religiousness			.04				.25**	.24**

Hierarchical regression analysis: *step 1* age and sex as predictors, *step 2* age, sex, and personality traits as predictors, *step 3* age, sex, personality traits, parental and peer religiousness as predictors, *Best* best model based on stepwise inclusion and exclusion of predictors in regression analyses

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits

Table 3 Correlations among potential predictors of individual religiousness

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age		.04	-.03	.22**	.05	.18**	-.12*	-.17**	-.06	.20**	.19**	.18**
2. Sex	.00		.15**	.24**	.18**	-.01	-.21**	-.13*	.08	.07	.01	-.11*
3. Openness	-.06	.21**		.21**	.06	-.02	-.04	.01	-.01	.03	.04	-.00
4. Agreeableness	.07	.19**	.21**		.14*	.02	.04	-.03	.03	.14**	.06	.06
5. Conscientiousness	.16**	.02	.00	.13**		-.09 ⁺	.00	-.05	-.03	.03	-.02	-.03
6. Warmth ^a	.03	-.01	.04	.05	.07		-.36**	.06	-.13*	.06	.05	.02
7. Excitement seeking ^a	-.14**	-.15**	-.03	.02	.00	-.35**		-.10 ⁺	.16**	-.04	-.06	-.05
8. Openness to values ^a	.14**	-.08	-.01	-.02	.02	.05	-.05		-.02	-.16**	-.03	-.19**
9. Modesty ^a	.05	-.02	-.03	-.04	-.01	-.16**	.04	-.04		-.15**	-.16**	-.12**
10. Parental rel.	.04	.11*	.06	.14**	.12*	.04	-.08	-.14**	-.14**		.36**	.32**
11. Best friend rel.	.10 ⁺	-.01	.05	.03	-.01	.01	-.05	-.11*	.01	.24**		.31**
12. Spouse rel.	.13 ⁺	-.01	.14 ⁺	.07	.07	.09	-.06	-.06	.04	.44**	.30**	

Below the diagonal: Age ≤ 30 ; above the diagonal: Age > 30

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits

Table 4 Correlations within monozygotic and dizygotic twins for both age groups

Variables	Age ≤ 30				Age > 30			
	MZT		DZT		MZT		DZT	
	<i>N</i>	<i>ICC</i>	<i>N</i>	<i>ICC</i>	<i>N</i>	<i>ICC</i>	<i>N</i>	<i>ICC</i>
Individual religiousness	116	.92**	78	.74**	109	.74**	90	.63**
Openness	116	.67**	78	.21 ⁺	109	.63**	89	.32**
Agreeableness	116	.59**	78	.31**	109	.38**	90	.25*
Conscientiousness	116	.67**	78	.42**	110	.49**	90	.12
Warmth ^a	116	.09	78	.10	109	.30**	89	.09
Excitement seeking ^a	116	.48**	78	.24*	109	.39**	89	.13
Openness to values ^a	116	.32**	78	.30**	109	.41**	89	.06
Modesty ^a	116	.26**	78	.32**	109	.46**	89	.23*
Parental religiousness	115	.81**	78	.73**	96	.68**	83	.74**
Best friend religiousness	94	.05	51	.01	83	.31**	75	.18
Spouse religiousness	46	-.03	25	.37 ⁺	83	.29**	60	.07

ICC intra-class correlation

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits

For older people, we also found a (partial) mediation for agreeableness ($z = 2.64$; $p < .01$), openness to values ($z = -2.97$; $p < .01$), and modesty ($z = -2.81$; $p < .01$). The age effect vanished in the presence of personality variables, perceived parental, best friend, and spouse religiousness. That is, older people reported higher levels of individual religiousness that could be (completely) mediated by higher levels of perceived religiousness of parents and peers.

Finally, the stepwise procedure yielded the best regression models (see Table 2) that accounted for more than a

half of variance in individual religiousness for both age subsamples. The facet residuals warmth and modesty as well as perceived best friend's and spouse's religiousness for the younger sample and excitement seeking for both age groups did not show significant links with individual religiousness in the presence of other potential predictor variables.

Univariate variance component analyses

For both age groups, we estimated twin correlations for individual religiousness and each potential predictor

Table 5 Univariate variance component model fitting results

Variables	Model	Model fit statistics				Genetic and environmental effects						Testing interaction with age
						Genetic		Environmental				
								Shared		Nonshared		
		χ^2	df	p	RMSEA	≤30	>30	≤30	>30	≤30	>30	$\Delta\chi^2(df)$
Individual religiousness	Full	10.06	6	.12	.042	.47** (22)	.36* (13)	.83** (69)	.77** (60)	.31** (9)	.52** (27)	34.01(3)**
Openness	Full	10.91	6	.09	.046	.81** (65)	.72** (53)	.00 (0)	.27 (8)	.59** (35)	.62** (37)	.54(3)
	Reduced	11.04	8	.20	.019	.81** (66)	.77** (61)	–	–	.59** (34)	.61** (39)	.40(2)
Agreeableness	Full	11.36	6	.08	.048	.79** (60)	.62** (42)	.00 (0)	.08 (1)	.64** (40)	.73** (57)	3.70(3)
	Reduced	11.36	8	.18	.033	.79** (60)	.63** (43)	–	–	.64** (40)	.73** (57)	3.70(2)
Conscientiousness	Full	8.78	6	.19	.034	.87** (70)	.65** (47)	.16 (2)	.00 (0)	.55** (28)	.69** (53)	9.52(3)*
	Reduced	8.80	8	.36	.016	.88** (72)	.65** (47)	–	–	.55** (28)	.69** (53)	9.50(2)**
Warmth ^a	Full	5.31	6	.51	.000	.07 (1)	.48* (29)	.23 (9)	.00 (0)	.70** (90)	.75** (71)	13.18(3)**
	Reduced	7.19	9	.62	.000	–	.48** (29)	–	–	.74** (100)	.75** (71)	23.06(2)**
Excitement seeking ^a	Full	5.50	6	.48	.000	.59** (49)	.52** (38)	.00 (0)	.00 (0)	.60** (51)	.67** (62)	1.43(3)
	Reduced	5.50	8	.70	.000	.59** (49)	.52** (38)	–	–	.60** (51)	.67** (62)	1.43(2)
Openness to values ^a	Full	8.92	6	.18	.035	.16 (5)	.54** (37)	.39* (27)	.00 (0)	.62** (68)	.71** (63)	13.40(3)**
	Reduced	8.95	8	.35	.017	–	.54** (37)	.41** (30)	–	.62** (70)	.71** (63)	47.95(3)**
Modesty ^a	Full	8.63	6	.20	.034	.00 (0)	.53** (46)	.47* (28)	.00 (0)	.75** (72)	.57** (54)	11.32(3)**
	Reduced	8.63	8	.37	.014	–	.53** (46)	.47** (28)	–	.75** (72)	.57** (54)	50.71(3)**
Parental religiousness	Full	6.03	6	.42	.004	.18 (3)	.00 (0)	.83** (75)	.83** (71)	.45** (22)	.53** (29)	5.07(3)
	Reduced	6.17	8	.63	.000	–	–	.85** (78)	.83** (71)	.45** (22)	.53** (29)	4.98(2) ⁺
Best friend religiousness	Full	.80	6	.99	.000	.19 (4)	.49* (24)	.00 (0)	.25 (6)	.92** (96)	.84** (70)	5.18(3)
	Reduced	1.42	9	1.00	.000	–	.56** (31)	–	–	.94** (100)	.83** (69)	12.18(2)**
Spouse religiousness	Full	4.64	6	.59	.000	.00 (0)	.55* (30)	.31 (11)	.00 (6)	.90** (89)	.84** (70)	3.04(3)
	Reduced	5.55	9	.78	.000	–	.55** (30)	–	–	.96** (100)	.84** (70)	8.73(2)**

Standardized variance components are shown in brackets

** $p < .01$; * $p < .05$ ^a Personality facet residuals corrected for variance in Big Five personality traits

“–” Parameters fixed to zero

variable (see Table 4). Intra-Class Correlations indicated a strong contribution of shared environmental effects for individual and perceived parental religiousness, whereas twin correlations indicated a strong component of nonshared environmental effects for perceived spouse's and best friend's religiousness. For personality variables, twin correlations pointed to genetic and nonshared environmental effects as primary sources of variance.

Univariate twin model fitting results (shown in Table 5) yielded a strong contribution of shared environmental effects to the variance in individual religiousness as well as moderate genetic and nonshared environmental influences. In line with our expectations, shared environmental effects on individual religiousness were smaller for the older age group and nonshared environmental effects were larger. Not in line with our hypothesis, genetic effects on individual religiousness tended to decrease across age.

Not surprisingly, the Big Five personality traits openness, agreeableness, and conscientiousness were primarily affected by genetic factors and nonshared environmental effects that did not vary markedly across different age samples (except for conscientiousness). For facet residuals we found a different picture: Nonshared environmental effects represented the main source of variance and shared environmental effects significantly contributed to facet-specific variance in openness to values and modesty for younger ages, whereas genetic effects significantly contributed to the variance in older ages. As expected, shared environmental effects accounted for the most of the variance in perceived parental religiousness and nonshared environmental effects accounted for the most of the variance in perceived best friend's and spouse's religiousness for both age groups.

Multivariate variance component analyses

Using a Cholesky decomposition model (see Fig. 1), we tested whether the links from personality traits, parental and peer religiousness to individual religiousness were genetically or environmentally mediated. We also estimated the proportions of genetic and environmental variance in individual religiousness common with genetic and environmental variance in potential predicting variables and specific for individual religiousness. Based on the results of the multiple hierarchical regression analyses we ran reduced Cholesky models for both age groups. For the younger twins, we only included the personality domain traits openness, agreeableness, and conscientiousness, the personality facet residual openness to values, and parental religiousness as significant predictors of individual religiousness into the model (i.e., $g_{PS} = 0$ and $e_{PS} = 0$, see Fig. 1). The resulting model was a six-variable Cholesky model with 93 degrees of freedom (see 1. full model in

Table 6 for age ≤ 30). For the older twins, we included the personality domain traits openness and agreeableness, the personality facet residuals warmth, openness to values, and modesty, as well as perceived parental, best friend's, and spouse's religiousness in the model resulting in a nine-variable Cholesky model with 207 degrees of freedom (see 1. full model in Table 6 for age > 30). The full Cholesky models (with three sources of variance) were strongly saturated and had low statistical power due to our relatively small sample size to estimate significant genetic links in presence of shared environmental links. Therefore, we first tested more parsimonious models according to the results of the univariate variance component analyses (see Table 5). That is, we fixed non-significant genetic and environmental factors (e.g., shared environmental effects on domain personality traits or genetic effects on perceived parental religiousness) and the respective bivariate pathways with other variables to zero. This strategy did not yield significant reductions in model fit (i.e., insignificant $\Delta\chi^2$), but increased the overall fit of a model (see 2. reduced model in Table 6).

Based on these reduced models, we first tested the genetic (model 3a, for the three personality domain traits), the shared environmental (model 3b, for openness to values), and the nonshared environmental (model 3c) contributions to the associations between personality traits and individual religiousness for the younger age sample. Model comparisons yielded that these links were due to genetic influences and shared environmental effects but not due to nonshared environmental influences. For the older age group, the relations between individual religiousness and personality traits were entirely attributable to genetic associations.

Then, we tested whether the links between individual religiousness and perceived parental religiousness were mediated by shared (model 3d for the younger sample and 3c for the older group) or nonshared environmental effects (model 3e for the younger sample and 3d for the older group). As expected, the links were significantly mediated by shared but not by nonshared environmental effects for both age samples. Since perceived best friend's and spouse's religiousness accounted for additional variance in individual religiousness in the older age sample (see Table 2), we finally tested whether these links were genetically (model 3e) and (or) environmentally (model 3f) mediated. Model comparisons yielded that both genetic as well as nonshared environmental effects accounted for the links between perceived peer (i.e., best friend and spouse) religiousness and individual religiousness.

Table 7 for the younger subsample and Table 8 for the older group represent latent genetic and environmental correlations between individual religiousness and potentially predicting variables. The last two rows in Table 7 and 8 show the genetic and environmental variance

Table 6 Multivariate variance component model fitting results: model tests

Models	Model fit indices				
	χ^2	<i>df</i>	<i>p</i>	RMSEA	$\Delta\chi^2(df)$
Age ≤ 30 ($N_{MZ} = 116$; $N_{DZ} = 78$)					
1. Full model	137.74	93	.00	.071	
2. Reduced model vs. model 1	155.58	119	.01	.057	17.84(26)
Testing relations with personality traits ^a					
3a. No common G vs. model 2	172.81	122	.00	.066	17.23(3)**
3b. No common C vs. model 2	166.11	120	.00	.063	10.53(1)**
3c. No common E vs. model 2	157.66	123	.02	.055	2.08(4)
Testing relations with parental religiousness					
3d. No common C vs. model 2	171.96	120	.00	.068	16.38(1)**
3e. No common E vs. model 2	156.60	120	.01	.057	1.02(1)
Best Fitting Model:					
4. Model 3c + 3e vs. model 2	158.69	124	.02	.054	3.11(5)
Age > 30 ($N_{MZ} = 110$; $N_{DZ} = 90$)					
1. Full model	281.99	207	.00	.063	
2. Reduced model vs. model 1	303.91	256	.02	.043	21.92(49)
Testing relations with personality traits ^b					
3a. No common G vs. model 2	336.74	261	.00	.056	32.83(5)**
3b. No common E vs. model 2	309.81	261	.02	.044	5.90(5)
Testing relations with parental religiousness					
3c. No common C vs. model 2	430.22	257	.00	.085	126.31(1)**
3d. No common E vs. model 2	303.99	257	.02	.043	.07(1)
Testing relations with best friend and spouse religiousness					
3e. No common G vs. model 2	309.66	258	.02	.044	5.75(2) ⁺
3f. No common E vs. model 2	311.62	258	.01	.046	7.71(2)*
Best Fitting Model					
4. Model 3b + 3d + 3e vs. model 2	309.89	262	.02	.043	5.98(6)

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Openness, agreeableness, conscientiousness, and openness to values (R)

^b Openness, agreeableness, warmth (R), openness to values (R), and modesty (R)

R = Personality facet residuals corrected for variance in Big Five personality traits

components in individual religiousness shared (i.e., explained) and not shared (i.e., residual) with potentially predicting variables.³ Genetic effects on personality traits accounted for a significant proportion of the genetic variance in individual religiousness. For both age groups, shared environmental effects on perceived parental religiousness accounted for the most of the shared environmental variance in individual religiousness. Genetic effects on perceived best friend and spouse religiousness were

significantly correlated with genetic effects on individual religiousness of older twins, whereas only perceived spouse religiousness showed a significant nonshared environmental overlap with individual religiousness.

Discussion

In the current study, we examined the roles of genetic and environmental factors on the variance in personality traits, perceived parental religiousness, and perceived peer religiousness as etiological sources of the genetic and environmental variance in individual religiousness. In the following section, we will discuss our results and their implications.

In line with most previous studies (e.g., Button et al. 2011; Koenig et al. 2005; Bradshaw and Ellison 2008), we

³ Note, the latent correlations between genetic or environmental factors of two different variables can be larger than the phenotypic correlations. Phenotypic level includes genetic and environmental components. If the phenotypic links, for example between personality and religiousness, are primarily genetically mediated, then the genetic correlations are larger and the environmental correlations are smaller than the phenotypic links. Consequently, the explained genetic variance component is larger than the explained phenotypic variance.

Table 7 Multivariate variance component model fitting results: genetic and environmental parameter estimates for age ≤ 30

Models	Genetic and environmental parameters								
	Genetic			Environmental					
				Shared			Nonshared		
	Full	Reduced	Best	Full	Reduced	Best	Full	Reduced	Best
	Latent correlations with individual religiousness								
	r_G			r_{SE}			r_{NSE}		
Openness	.38*	.38**	.41**	.12	–	–	.05	.06	–
Agreeableness	.68**	.42**	.40**	–.15	–	–	–.05	–.01	–
Conscientiousness	.38*	.38**	.32**	–.02	–	–	–.13	–.11	–
Openness to values ^a	–.36	–	–	–.35 ⁺	–.37**	–.39**	–.01	–.04	–
Parental rel.	.75 ⁺	–	–	1.0**	.99**	.99**	–.15 ⁺	–.08	–
Variance components in individual religiousness									
	V_G			V_{SE}			V_{NSE}		
Explained	.20**	.04**	.04**	.71**	.76**	.75**	.00	.00	.00
Residual	.00	.10**	.11**	.00	.00	.00	.09**	.10**	.10**

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits; *Full* Model 1 in Table 6, *Reduced* Model 2 in Table 6, *Best* Model 4 in Table 6, dashes represent parameters that are fixed to zero, r_G genetic correlation, r_{SE} shared environmental correlation, r_{NSE} nonshared environmental correlation, V_G genetic variance component, V_{SE} shared environmental variance component, V_{NSE} nonshared environmental variance component

“–” Parameters fixed to zero

found a significant genetic contribution to the variance in individual religiousness for both age groups. Inconsistent with our expectations and previous studies, heritability did not increase across the focused age groups. This might have different reasons. On the one hand, previous genetically informative studies, which found an increase of heritability across age (e.g., Koenig et al. 2008; Button et al. 2011), have focused on adolescents and younger adults, whereas our study focused on late adolescents and younger adults as one group and middle and late adults as another group. Our data suggest that genetic effects on the variance in individual religiousness remain relatively constant or even slightly decreased again after young adulthood. On the other hand, the difference between the younger and older group in our study can reflect a cohort effect. The older cohort might have been raised with a more severe religious upbringing compared to the younger cohort. Consistent with this consideration, the number of undenominational people dramatically increased in Germany from 5 % in 1970 to 35 % in 2008 (see www.fowid.de) and the younger cohort in our study in fact showed lower levels of religiousness. Genetically informative longitudinal research is needed here that may provide further insight into the developmental patterns of genetic effects on individual religiousness across adulthood.

In the current study, it was of interest to understand the nature of genetic influences on the variance in individual

religiousness. We suggested that personality traits may be promising candidates that may mediate genetic contributions. Controlled for age and sex as well as for self-rater bias, the personality traits agreeableness and conscientiousness (at least for the younger adults) showed positive links to individual religiousness. This finding is consistent with a recent meta-analysis (Saroglou 2010) which found that agreeableness as well as conscientiousness was significantly correlated with religiousness. Seemingly in contrast to the previous study, we found positive associations between openness and religiousness. However, previous studies (e.g., Saroglou 2010; Wink et al. 2007) differentiated between religiosity and spirituality as different facets of religiousness. These studies showed significant positive links between openness and spirituality. In our study, we did not differentiate between different facets of religiousness. Some people may rate themselves as religious in terms of spirituality (i.e., beliefs and practices that refer to a transcendent seeking independent from established religious traditions and customs), whereas others rate themselves as religious within the meaning of religiosity (i.e., beliefs and practices that are legitimized by an established tradition or religious group).

Corrected for variance in Big Five personality traits we also found significant links to facet traits. The negative associations with openness to values and excitement seeking as well as the positive relationship with warmth are in line

Table 8 Multivariate variance component model fitting results: genetic and environmental parameter estimates for age > 30

Models	Genetic and environmental parameters								
	Genetic			Environmental					
				Shared			Nonshared		
	Full	Reduced	Best	Full	Reduced	Best	Full	Reduced	Best
	Latent correlations with individual religiousness								
	r_G			r_{SE}			r_{NSE}		
Openness	.73*	.26*	.22*	-.19	–	–	-.03	-.02	–
Agreeableness	.30	.23	.24 ⁺	.21	–	–	.06	.06	–
Warmth ^a	.35	.19	.28 ⁺	.21	–	–	.08	.09	–
Openness to values ^a	-.58	-.55**	-.61**	-.38	–	–	-.13	-.14	–
Modesty ^a	-.50	-.54**	-.59**	-.57 ⁺	–	–	-.10	-.08	–
Parental rel.	.44	–	–	.89**	.95**	1.0**	.00	.03	–
Best friend rel.	.46	.65**	.65**	.87	–	–	.01	.02	.04
Spouse rel.	.46	.61**	.61**	.85	–	–	.26**	.23**	.23**
Variance components in individual religiousness									
	V_G			V_{SE}			V_{NSE}		
Explained	.13**	.23**	.28**	.60**	.44**	.44**	.03*	.03*	.02 ⁺
Residual	.00	.00	.00	.00	.04	.00	.24**	.26**	.26**

** $p < .01$; * $p < .05$; ⁺ $p < .10$

^a Personality facet residuals corrected for variance in Big Five personality traits, *Full* Model 1 in Table 6, *Reduced* Model 2 in Table 6, *Best* Model 4 in Table 6, dashes represent parameters that are fixed to zero, r_G genetic correlation, r_{SE} shared environmental correlation, r_{NSE} nonshared environmental correlation, V_G genetic variance component, V_{SE} shared environmental variance component, V_{NSE} nonshared environmental variance component

“–” Parameters fixed to zero

with Saroglou's (2010) meta-analysis. Though the meta-analysis did support positive links to all agreeableness-related facets except modesty, we found a negative link with modesty. This might be due to the fact that we corrected the facet scores for their domain trait components. Consequently, the higher-order trait agreeableness that account for the positive associations between religiousness and all agreeableness-related facets might act as a suppressor of the negative association between modesty and religiousness.

In accordance with our hypotheses, the relationships between individual religiousness and personality traits were primarily genetically mediated. However, the associations between personality traits and individual religiousness were not significantly larger for middle and late adults compared to late adolescents and young adults (except for modesty). This ran contrary to our expectations but consistent with the aforementioned finding that genetic influences did not increase across adulthood. Generally, the links between personality traits and individual religiousness were rather small. Personality traits alone could not account for the entire genetic variance in individual religiousness in the younger subsample and beyond genetic variance in perceived religiousness of important others in the older subsample. This allows different implications.

First, other basic attributes strongly influenced by genetic effects might account for additional genetic variance in individual religiousness, such as cognitive abilities (e.g., intelligence) or volitional characteristics (e.g., interests). In line with this claim, Lynn and colleagues (2009) found a strong negative correlation between IQ and religious belief across 137 countries.

Second, individual religiousness itself may reflect a basic individual attribute rather than an outcome. However, most longitudinal studies found that personality traits predict religiousness rather than the reverse (McCullough et al. 2003; Wink et al. 2007). The latter supports the suggestion that religiousness can be understood as cultural adaptation of basic genetically anchored human attributes including (but not exclusively) personality traits (McCrae and Costa 2008; Saroglou 2010).

Finally, genetic effects on individual religiousness may reflect to some degree genotype-environment correlation (Scarr and McCartney 1983). Our results indicate a potential contribution of genotype-environment correlation between the genetic effects on individual personality traits and perceived parental religiousness. The effects of personality on individual religiousness decreased after the inclusion of parental religiousness in the regression model

and the explained genetic variance in individual religiousness decreased after genetic links from perceived parental religiousness to individual religiousness were excluded (for the younger subsample), even though the genetic effects on the variance in perceived parental religiousness were not significant.

Beyond personality traits, perceived parental religiousness was the strongest predictor of individual religiousness for both age groups. In line with our hypotheses, the associations were primarily mediated by environmental effects shared by twins raised in the same family. Moreover, perceived parental religiousness was more important for younger adults than for older adults accounting for a decrease of shared environmental variance in individual religiousness across age. That is, parents and their religious beliefs and practices appear to act as a role model for one's own religiousness across the entire life span but the influence of this role model is more pronounced in younger ages. As already mentioned, we further found evidence for passive genotype-environment correlations: perceived parental religiousness partially mediated the effects of personality on individual religiousness. For example, (1) more agreeable parents who are less open to new values have more agreeable offspring with lower openness to values due to their shared genetic makeup and (2) those parents provide more religious environments resulting in higher levels of individual religiousness in their offspring.

Also consistent with our hypothesis, the importance of perceived religiousness of best friends and spouses for individual religiousness increased across adulthood. However, not in line with our expectations, the relationship was primarily genetically mediated. In the first instance, this was surprising because we considered perceived peer religiousness as primary environmentally mediated predictor of individual religiousness not shared by twins raised in the same family. However, the similarity to spouses and to best friends may result from reciprocal assortment. Similarity of spouses and of best friends is about as large as the similarity of siblings in most psycho-social attributes. Genetically identical (monozygotic) twins choose more similar spouses and best friends than do fraternal (dizygotic) twins indicating that preference for similarity itself is genetically influenced (Rushton and Bons 2005). These findings explain why we found genetic variance in perceived best friend's and spouse's religiousness for older adults and why the association between individual religiousness and peer religiousness was primarily due to genetic sources.

Our findings also provide support for a small environmental contribution to the associations between perceived spouse and individual religiousness accounting for individual-specific environmental effects on individual religiousness after age 30. Maybe, young adults often try to

expand the self and gain new information, they try actively to change the environments and partnerships to match their goal pursuits, whereas older adults more often try to stabilize and protect the quality of life and ongoing relationships, they rather change the self to fit the environment (see McAdams and Olson 2010, for a review). This latter position can also explain why heritability of religiousness may initially increase from adolescents to young adults (Koenig et al. 2008; Button et al. 2011) and then decreases again from young to late adults (in our study). Active genotype-environment correlation may reflect an increase of heritability, whereas an adaptation in (social) environments may explain a decrease of heritability.

Although we did not directly measure parental and spouse religiousness, the relatively high correlations between perceived mothers' and fathers' religiousness and between twins' and perceived spouses' religiousness are consistent with the finding of relatively high assortative mating for religiousness (Rushton and Bons 2005). The presence of assortative mating for religiousness in a sample of twins may have resulted in an overestimation of shared environmental influences and an underestimation of genetic effects if assortative mating was due to genetically influenced assortment. Genotypic assortative mating acts to increase the genetic and, thus, the phenotypic similarity among offspring (e.g., DZ twins) but it does not lead to an increase of the similarity of already genetically identical MZ twins. The genetic influence on the variance in perceived spouse religiousness supports a contribution of genotypic assortative mating. However, if genotypic assortative mating would exclusively mimic shared environmental effects then genetic and shared environmental effects on the variance in individual religiousness would be similar across age. The estimates of shared environmental contributions, however, decreased from younger to older adults. Also, spouse correlations increased from younger twins ($r = .33$) to older twins ($r = .45$) to parents of twins ($r = .66$). Thus, real environmental influences should also account for the spouse correlations, such as social homogamy (e.g., shared religious and cultural macro-context) and spouse-specific micro-contexts (e.g., shared religious community and friends) or even reciprocal effects between spouses that can act to increase spouse similarity across age (see Kandler et al. 2012, for a review on different sources of assortative mating).

Our study was the first which examined the nature of the links between personality traits and religiousness as well as between perceived religiousness of important social interaction partners and individual religiousness. Yet, there were a number of limitations to this study. First, the results derived from German data may not be generalizable to other countries, nations, and cultures. Second, monozygotic and female twins were overrepresented. Third, with our

measurement of religiousness we lack the means to make the distinction between different facets of religiousness seen in the literature (e.g., religiosity, spirituality, and religious fundamentalism; see Saroglou 2010). Our study is informative about the raters' own concept of religiousness, but this does not mean that it represents the global concept of religiousness. Different raters may have different concepts. Fourth, only half of the younger sample had a spouse. Even though individuals with partners did not show different levels of individual religiousness, they were different from participants without partners in some personality variables (see footnote 1). This range restriction in the younger sample may have led to differences between the younger and older sample regarding the effects of spouse religiousness on individual religiousness. Finally, our data was cross-sectional and could neither distinguish between time, age, and cohort effects nor examine reciprocal effects between personality and religiousness or between individual religiousness and religiousness of important others across time. We couldn't take the reciprocal interplay between genetic and environmental effects into account. Though longitudinal studies have consistently shown that personality traits predict religiousness rather than vice versa (McCullough et al. 2003; Wink et al. 2007), a reverse causation is not improbable (i.e., religion make shape personality). For instance, Boomsma et al. (1999) found that heritable effects on disinhibition are moderated by religious upbringing.

Nevertheless, the current study was able to show that the heritability of individual religiousness can be explained by genetic variance in personality traits. The strong contribution of environmental influences to the variance in individual religiousness shared by twins may be due to a parental role model. The importance of parental religiousness, however, seems to decrease across age. Perceived religiousness of spouses and best friends, on the other hand, appears to gain more and more importance in later adult life, perhaps through reciprocal influences partially mediated by genotypic assortment. More research is needed that should be longitudinal and genetically informative to overcome the limitations of the current study. Future studies should examine the mechanisms of the potential interplay between genetic sources (e.g., genetically anchored basic traits) and both micro- and macro-contextual influences (e.g., social environments and culture) contributing to individual religiousness.

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